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ABSTRACT

The Appalachian Education Satellite Project (AESP) was designed to apply communications satellite technology to the task of improving the quality of education in Appalachia. This report is the 10th in a 12 volume series. To justify the cost of using the satellite method, a cost model was developed. This cost model provided information on: (1) the cost to develop, produce, transmit, and handle each of the learning activities in the courses produced by the AESP; (2) the effect on course costs of adding or deleting learning activities; (3) the per-student cost variance as a function of the various factors; and (4) the point where education by satellite is efficient in relation to alternative methods of instruction. Twelve figures illustrate the formulas for calculating what it costs to develop, produce, and evaluate the different AESP learning activities. Eleven tables of cost estimates are also included. Detailed information that breaks down the cost of each element is appended. (Author/DS)

COST ESTIMATION MODEL FOR ALTERNATIVE FORMATS AND DELIVERY MODES

appalachian education satellite project

Technical Report

number 10

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September, 1975

The Technical Report Series of the Appalachian Education Satellite Project is edited and published by the RCC Evaluation Component at the University of Kentucky, Lexington, Kentucky.

The purpose of this series is to document and disseminate information about the design, implementation and results of the AESP experiment.

William J. Bramble and Cathy Whitton

Editors

TECHNICAL REPORT SERIES #1 - 12

1. AESP Data Base Information: Rationale, Data Collection Procedure, Interpretation of Results. Prepared by William J. Bramble, Claudine Ausness, Larry Harding and Robert Wetter. Winter 1973.

2. An Experiment in Educational Technology: An Overview of the Appalachian Education Satellite Project. Prepared by Claudine Ausness and Betty Bowling. March, 1974.

3. Formative Evaluation Study for AESP Diagnostic and Prescriptive Reading Courses. Prepared by William J. Bramble, Claudine Ausness and Robert Wetter. October, 1974.

4. The Evaluation Design: Summer Courses, 1974. Prepared by William J. Bramble, Claudine Ausness, Robert Wetter and Larry Harding. December, 1974.

5. Performance of AESP Transmission/Reception Equipment (Summer and Fall, 1974). Prepared by William J. Bramble, Claudine Ausness and James R. Freeman. July, 1975.

6. User Ratings of Instructional Activities: Diagnostic and Prescriptive Reading Instruction, Summer, 1974. Prepared by Rodger Marion, William J. Bramble, Robert Wetter and Cathy Whitton. July, 1975.

7. User Ratings of Instructional Activities: Career Education in the Elementary Grades, Summer, 1974. Prepared by Larry Harding, William J. Bramble and Rodger Marion. August, 1975.

8. User Achievement: Diagnostic and Prescriptive Reading Instruction Course, Summer, 1974. Prepared by William J. Bramble, Rodger Marion and Claudine Ausness. August, 1975.

9. User Achievement: Career Education in the Elementary Grades, Summer, 1974. Prepared by Rodger Marion, William J. Bramble and Claudine Ausness. August, 1975.

10. Cost Estimation Model for Alternative Course Formats and Delivery Modes. Prepared by William J. Bramble, Claudine Ausness, and Donna Mertens. September, 1975.

11. Summative Evaluation of Career Education in the Secondary School Course, Fall, 1974. Prepared by Diane Maynard, Rodger Marion and William J. Bramble. September, 1975.

12. Summative Evaluation of Diagnostic and Prescriptive Reading Instruction K-6 Course, Spring, 1975. Prepared by William J. Bramble, Diane Maynard and Rodger Marion. September, 1975.

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INTRODUCTION

In May 1974 the National Aeronautics and Space Administration launched the sixth in its series of Applied Technology Satellites. To show different ways this satellite might be used, more than two dozen scientific, technical, and educational experiments were planned. They included experiments in satellite-to-satellite communications, instructional television via satellite, and medical conferences via satellite.

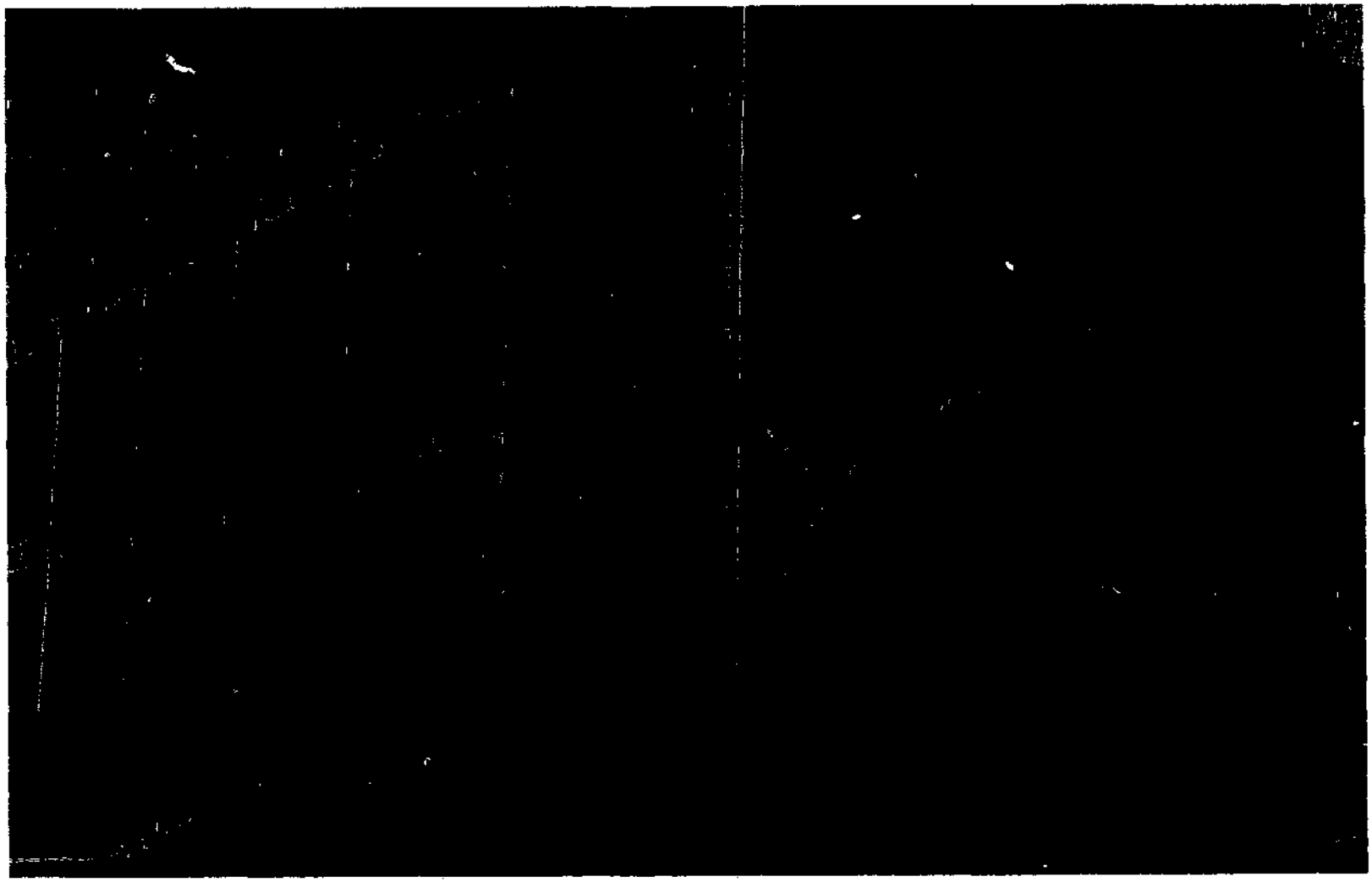
One experiment, sponsored by the National Institute of Education, was the Appalachian Education Satellite Project (AESP). The use of ATS-6 and ATS-3 to deliver in-service education courses to Appalachian teachers was proposed by the Appalachian Regional Commission (ARC). ARC was established in 1965 to promote the overall development of the Appalachian region through the construction of highways and hospitals, the reclamation of land, and the promotion of educational improvements. Thus AESP was consistent with the goals of ARC. Televised instructional materials delivered by satellite seemed to be one way to improve the quality of in-service teacher education, since classroom instruction could be supplemented with demonstrations showing Appalachian teachers applying exemplary instructional procedures in their classrooms.

In Appalachia where needs may be great but communities can least afford the expense, costs for reception equipment are a major factor. For this reason, ATS-6 was especially appropriate, since inexpensive ground antenna systems, costing about $4,000 could be used, instead of larger

antennas, costing hundreds of thousands of dollars, that previous satellite reception systems required (Lusignan, Potter, and Janky, 1975). The ATS-6 ground reception system antennas are shown in the picture on the following page.

Fifteen sites, scattered from New York to Alabama, were selected to receive the satellite-delivered courses produced by the Appalachian Education Satellite Project. With the cooperation of existing Regional Education Service Agencies (RESAs), the classroom sites were located in a variety of places including high schools, vocational schools, and junior colleges.

AESP offered a total of four courses - two in reading and two in career education - between the Summer of 1974 and the Spring of 1975. The reading courses were designed to teach Diagnostic and Prescriptive Reading Instruction (DPRI) and the career education courses were designed to train teachers to integrate career education concepts into their classrooms. All of the courses were offered for three hours of graduate credit. The reading (DPRI K-3) and career education (CEE) courses for elementary level teachers were offered in the Summer of 1974. These two courses consisted of 12 half-hour taped programs, 12 fifteen-minute audio reviews, 12 laboratory sessions, and 4 live interactive seminars. In the Fall of 1974, the career education (CES) course for junior and senior high school educators consisted of 16 live one-hour seminars and 15 laboratory sessions. The reading (DPRI, K-6) course offered in the Spring of 1975, consisted of 17 half-hour taped programs, 5 live one-hour seminars, 7 fifteen-minute audio reviews, and 16 laboratory sessions.



Audio-Video and Two-Way Radio Antennas
at Intensive Site in Cumberland, Maryland

Overall, each course was comprised of a certain number or combination of satellite-delivered activities and back-up or support materials such as those used in the lab sessions and those provided in classroom reference libraries.

Rather than discuss each course individually, this report focuses on a typical course, and the costs associated with the combination of learning activities for this course.

The University of Kentucky at Lexington, was chosen as the Resource Coordinating Center (RCC) for the development and evaluation of the AESP courses. As previously stated, specific instructional activities were used in various combinations throughout the courses. Each is described in some detail below.

1) One major instructional mode employed was a series of 30-minute, taped televised programs for each course offered, except the CES course. These programs differed from most graduate-level lectures in that they were punctuated with filmed interviews of teachers and content experts and segments showing Appalachian teachers applying instructional techniques in their classrooms. The televised programs were relayed from the broadcast studio to a powerful access antenna for transmission to ATS-6 and then broadcast to small ground antennas at the sites. The following picture shows students at a site watching a televised program.

2) Another satellite-delivered learning activity used in three of the four courses was a series of audio reviews of the taped television programs. Each review consisted of questions describing a

Students Watching CEE Television Program
at the Cumberland, Maryland, Site

hypothetical teaching situation and four alternative approaches to the problem. The student selected the response he felt was most appropriate by depressing a button on a response pad. The student then heard an explanation on the merits of the response. The audio reviews made use of the ATS-6 capability to simultaneously carry four audio channels on the same signal.

3) A third learning activity delivered by satellite was the live interactive seminar. Forum in format, the seminars made it possible for students to ask experts questions during live television broadcasts. The seminar questions were relayed from ancillary classroom sites, sites with landline teletype capability only, to main sites, sites with the capability to transmit questions to the broadcast studio via ATS-3. The CES course employed the seminar format exclusively. The CEE course and both DPRI courses incorporated 4-5 seminars into the planned programming.

4) The students also had access via ATS-3 to information retrieval systems that made use of computerized procedures. To supplement the materials available through computer searches, there were specially developed resource libraries at each site to make important back-up materials easily accessible.

5) In laboratory sessions the students had the opportunity to apply what they had learned from the televised programs. Supplementary instructional materials designed to augment the television and

four-channel audio instruction were used in completing prescribed lab activities. These activities provided opportunities for group interaction and a sharing of ideas. In addition, unit tests, used during the DPRI and the CEE courses, helped the students determine how well they understood the material covered in each unit.

Information collected by the AESP Evaluation Component helped answer many questions about course effectiveness, such as:

How reliable was the equipment used to transmit the taped and live television programs via satellite?

How well did the participants like the different learning activities?

How much did the students in each course learn?

Did the students change their attitudes toward principles fundamental to course objectives?

Answers to these and other questions about course effectiveness are detailed in the Technical Report Series published by the AESP Evaluation Component.

Briefly summarized, the results indicate that:

It is technically feasible using satellite delivery and inexpensive ground reception equipment to provide graduate education courses to students in dispersed geographical areas.

Site representatives who are non-content experts can administer these courses when provided with sufficient instructions and easy access to the Resource Coordinating Center by means of two-way radio.

Participants in the courses generally mastered the course content and are now applying what they learned in their classrooms.

The course participants preferred the learning activities in the satellite-delivered courses to on-campus graduate education courses with which they were familiar.

RATIONALE

Even if education by satellite is effective from an educational point of view, it still must be justified from a cost point of view. With more restricted educational budgets today than in the 1950's and 1960's, educational funding agencies and the tax-paying public want a well documented answer to the question, "Is this a good way to spend our money?" Another question of interest is: "How can we buy the best and most effective education?"

To obtain information on the costs of various products, the Resource Coordinating Center maintained a detailed bookkeeping system. To make these figures meaningful, it was necessary to develop a cost model to interrelate production costs associated with different learning activities to the costs associated with bringing the instruction to the students.

The cost model described in this report provided information helpful in answering a number of questions about project costs, such as:

1) How much did it cost to develop, produce, transmit and handle each of the learning activities in the courses produced by the AESP?

2) What is the effect on course costs of adding or deleting learning activities?

3) How does per-student cost vary as a function of the various factors?

4) At what point of expansion is education by satellite cost efficient, in relation to alternative ways of instruction?

METHOD

Identification of Cost Parameter

The four cost parameters associated with the AESP course development, production, delivery, and administration were: 1) the development and production of instructional and evaluative materials for in-service teacher education courses; 2) the broadcast and delivery of these materials from the Resource Coordinating Center (RCC) in Lexington, Kentucky, to local classroom sites in Appalachia; 3) the handling of course-related activities at each site and its surrounding community by Regional Education Service Agencies (RESAs); 4) the coordination of the AESP course activities by the RCC in Lexington, Kentucky and the overall project management by the AESP staff within the Appalachian Regional Commission in Washington. These four parameters provide the basis for the cost model and are discussed in the following sections.

The present version of the model supplies costs only for the formats actually implemented by AESP. Therefore, in the production parameter costs, formulas are given for the type and format of learning activities incorporated in the AESP courses. These included taped televised programs; live interactive televised seminars; audio reviews; laboratory activities; and on-site libraries expanded by access to computerized retrieval systems. The cost figures used in the model for the production parameter are based specifically on the cost of the Diagnostic and Prescrptive Reading course offered by AESP in the Summer of 1974 (DPRI, K-3). It should be noted that

all reported costs are those for the period of the original AESP grant (1973-1975). Inflationary factors have not been taken into account in the model.

Similarly, only satellite delivery is considered for the transmission of television and radio activities. An expanded version of the model might consider such alternative delivery systems as state-wide educational television networks, instructional television fixed service stations, site videotape libraries with closed circuit television, slide scenes for individualized study, or a number of other delivery options.

Costs associated with the remaining two parameters, local handling and central coordination also reflect the AESP structure, central coordination being managed by ARC and the management component at the production center (RCC) and local handling being performed by site coordinators and faculty consultants hired by participating RESAs. The costs in the model for these two parameters are not course specific as are the costs for production. Rather, the assumption was made that the costs for these two parameters were spread evenly over the four courses. Therefore, each course was assumed to account for one fourth of the total cost of these two parameters.

Identification of Types of Variables

There are two kinds of variables in the cost model: those that measure the number of units required, quantitative variables, and those that place dollar values on products and services, qualitative or normative variables. By combining these variables in various ways, it is possible to calculate how much it would cost to develop, produce, deliver, handle, and coordinate a variety of courses made up of different combinations of the options.

Identification of Data Collection Strategies

The estimates for the elements in the production, handling, and central coordination parameters were supplied by the Resource Coordinating Center at the University of Kentucky, that produced the evaluation and instructional materials for the AESP courses. Estimates for many elements in the delivery parameter were supplied by engineering personnel from the Federation of Rocky Mountain States. These persons were part of the group that was in charge of the ground equipment for all the health and educational experiments using ATS-6. It should be pointed out that the cost figures assigned each of these delivery elements are gross estimates. Again, these figures, based on contracts let in 1974, do not take into account increased costs due to inflation.

RESULTS

Description of Production Cost Formulas

In Figures 1, 2, 3, 4, and 5 the formulas for calculating what it cost to develop, produce, and evaluate the different AESP learning activities are given. The rectangles represent cost figures, dollar estimates of cost associated with the development of one unit of a particular product or activity associated with the diagnostic and prescriptive reading course. The variables representing the number of units being considered in the model (e.g., number of TV programs, number of students) are represented in the circles included in Figures 1-5. Appendices A, B, C, D, E and F detailed information that breaks down the cost of each element in these figures.

To see how the cost model works consider Figure 1. Figure 1 shows the part of the cost model that relates to the development, production, and evaluation of the taped 30-minute programs used in AESP courses. The three boxes within the brackets on the left-hand side of the equation contain the dollar cost for development, production, and evaluation for a single 30-minute taped program. These costs are $1,655, $6,120, and $1,138, respectively. The documentation for these costs appears in Appendixes A and B. The box on the right-hand side of the equation with brackets is the cost for analyzing the test results and other evaluation data per student

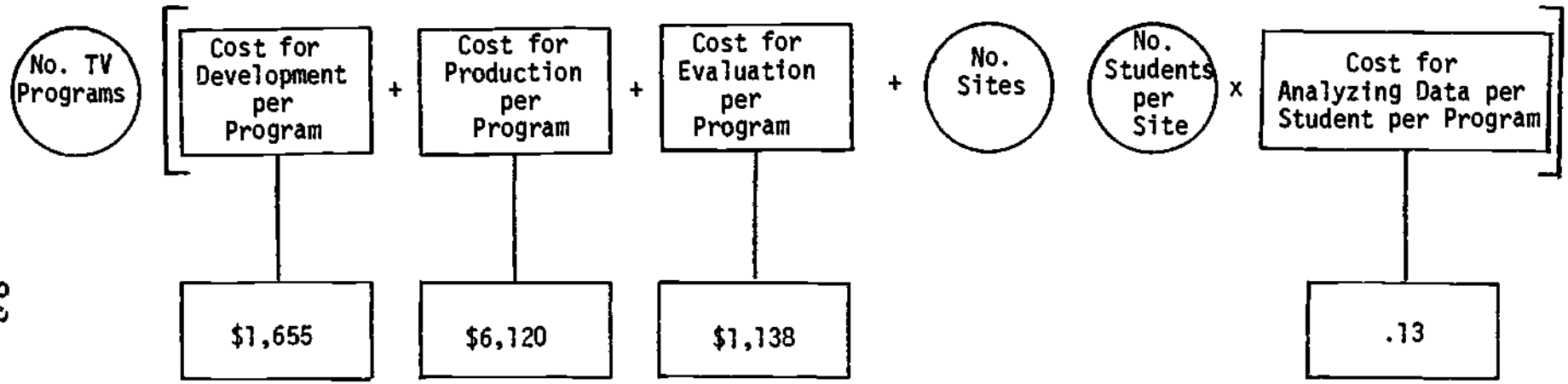


FIGURE 1: TAPED PROGRAM DEVELOPMENT, PRODUCTION, AND EVALUATION COST FORMULA

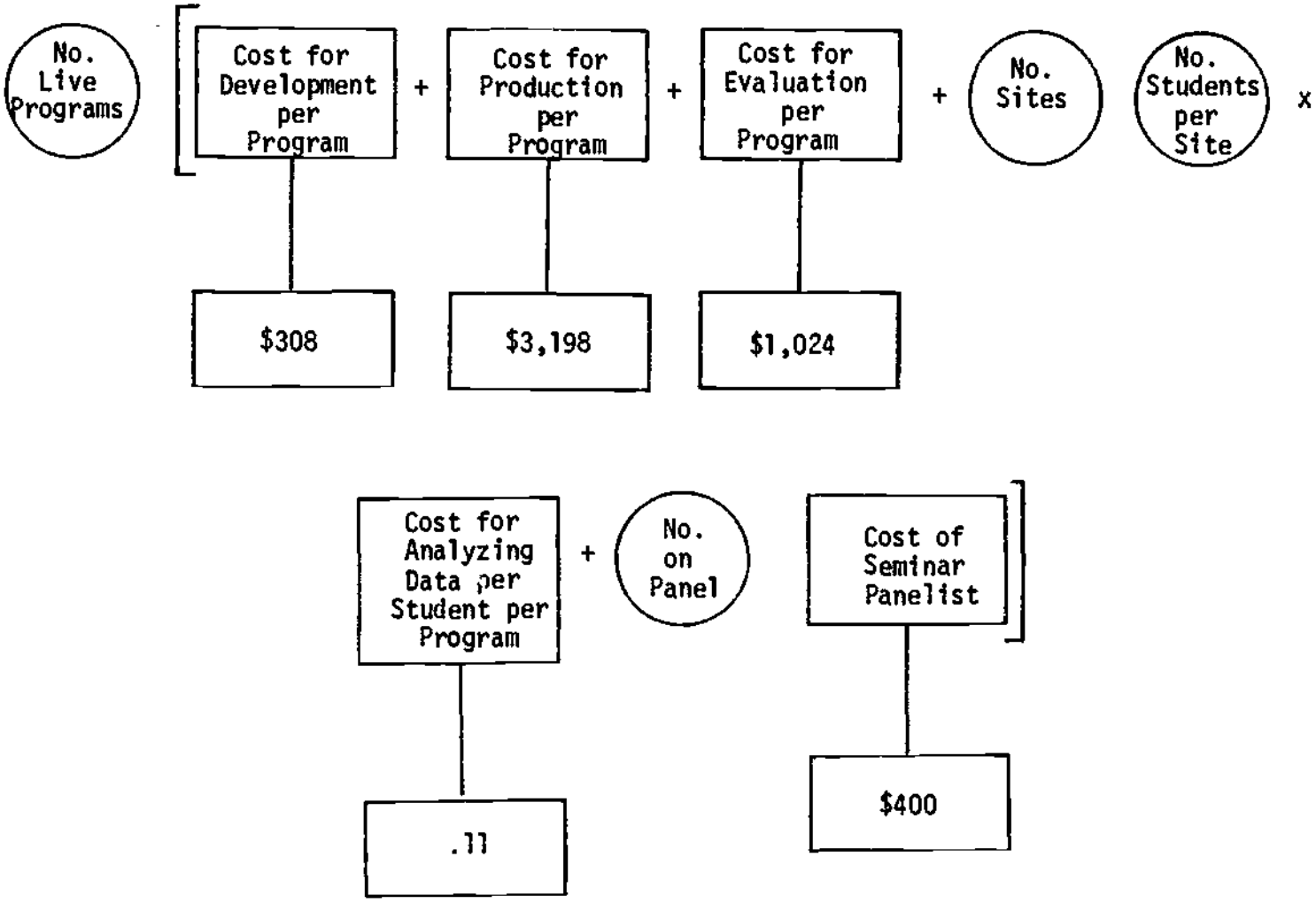


FIGURE 2: LIVE TELEVISION PROGRAM DEVELOPMENT, PRODUCTION, AND EVALUATION COST FORMULA

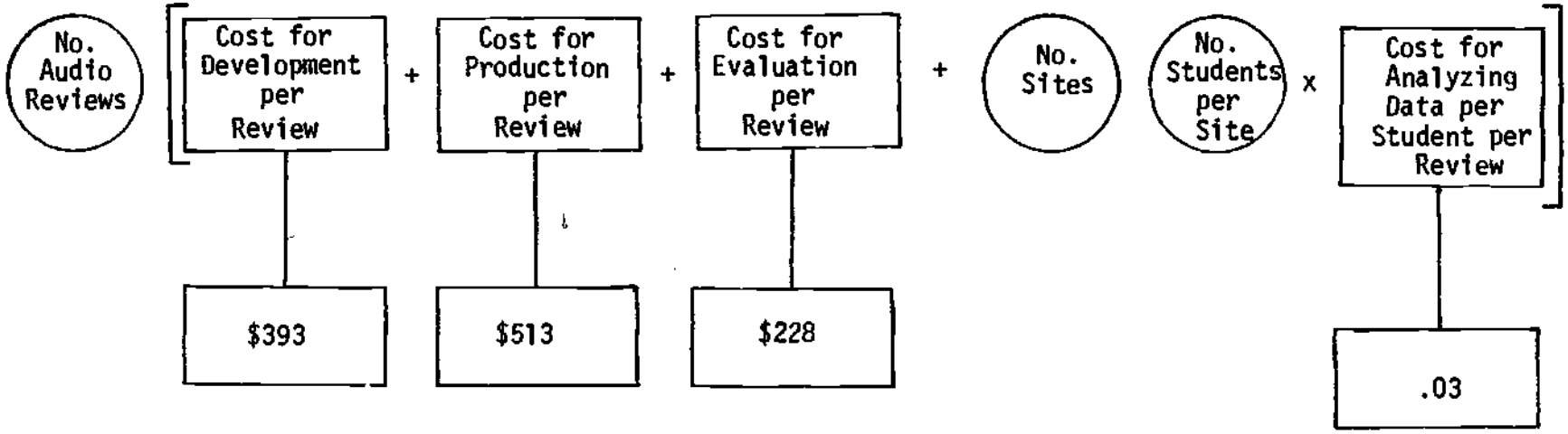


FIGURE 3: FOUR-CHANNEL AUDIO REVIEW DEVELOPMENT, PRODUCTION, AND EVALUATION COST FORMULA

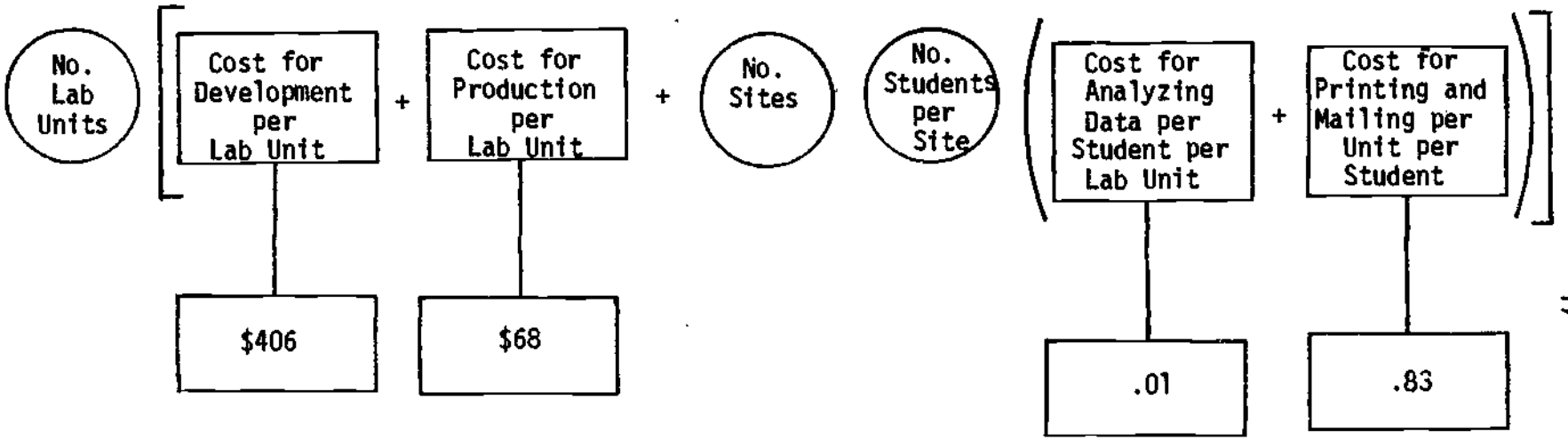


FIGURE 4: ANCILLARY ACTIVITIES DEVELOPMENT, PRODUCTION, AND EVALUATION COST FORMULA

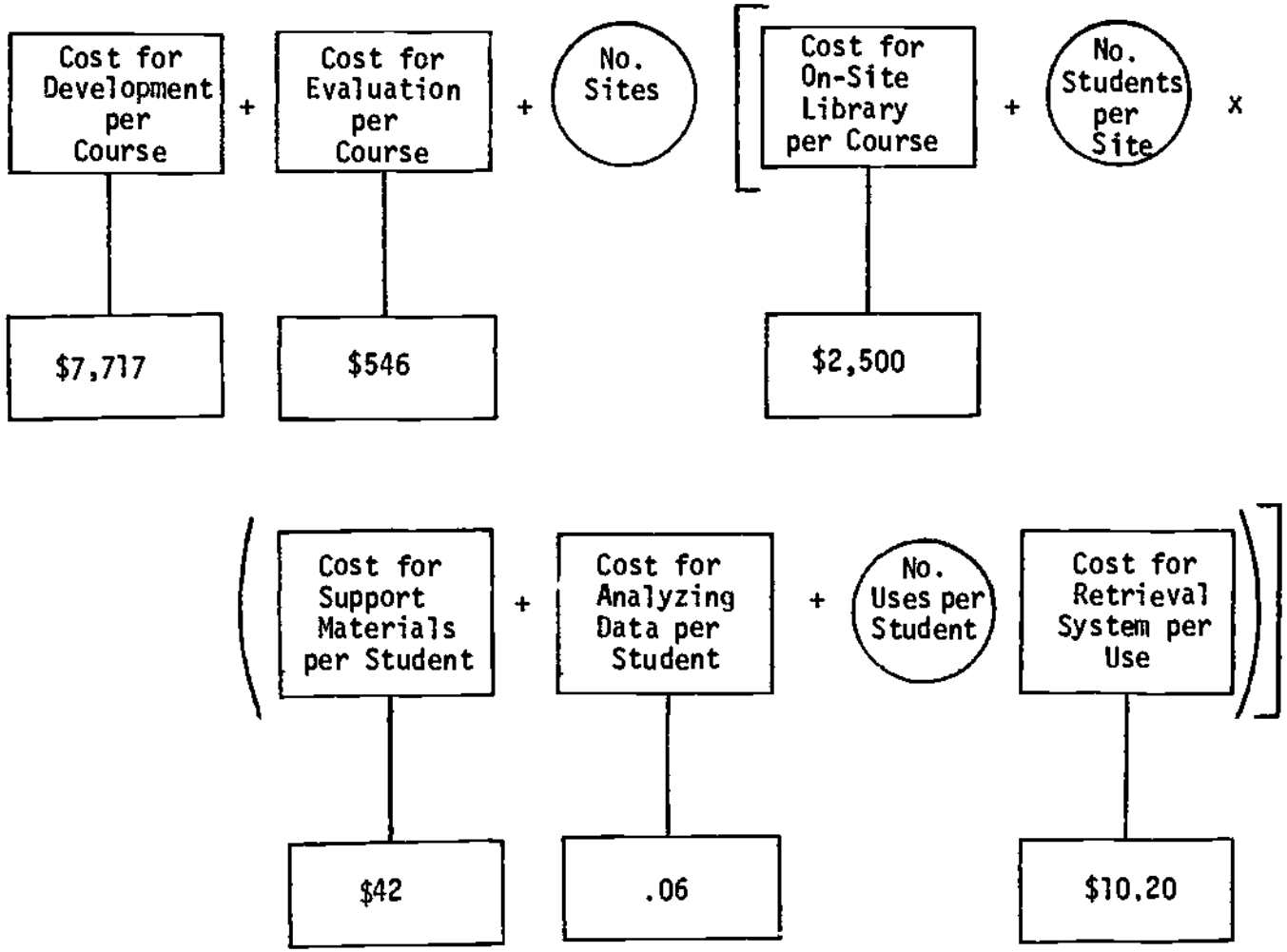


FIGURE 5: ON-SITE INFORMATION SUPPORT SYSTEM COST FORMULA

for a single program. These costs are also documented in Appendix B. The costs of data analysis per student need to be multiplied by the two circled items (number of sites X number of students per site) to obtain the data analysis costs per program for all students combined. the four terms within brackets are added toegether, the total cost per program of developing, producing, evaluating and analyzing the videotape materials is obtained. This total cost is then multiplied by the total number of taped TV programs included in the course (circled item outside the brackets at the far left of figure 1) to obtain the total cost for all taped programs for an AESP course. In the interest of brevity the other figures need not be described in this detail. The interpretation would, however, follow along the same lines.

A base figure of one unit was used to arrive at each dollar cost presented in the formulas. While this may be somewhat artificial, since producing 24 programs might not cost twice as much as 24 times 1, a base of 1 provides the flexibility necessary for manipulating the quantity of units. The base was formed by dividing by the number of units produced what it cost the AESP to develop, produce, and evaluate the entire learning package being considered. A limitation of a production cost formula developed this way is that no provision has been made for the decline in per unit cost that occurs in some cost analyses, when the number of units ordered at one time increases. Consequently, there is no economy of scale represented in the model and the resulting production cost parameter is likely to be inflated for cases involving large numbers of units.

A number of variables in the formulas can be altered to estimate costs for the AESP courses under different conditions. Two of the most important variables are audience size and number of programs. Tables 1, 2, 3, 4, and 5 present cost estimates for each component of the courses for different size audiences. Since the cost for developing, producing and evaluating a program is fixed, the more students who take a course, the less per student each activity in the course costs because the fixed production cost is distributed over a wider base of students.

TABLE 1

COST OF 12 TAPED TELEVISED PROGRAMS PRODUCTION

# of Sites with 20 Students/Site	# of Students	Cost	
		per Course	per Student
15	300	$107,424	$358.08
30	600	107,892	179.82
45	900	108,360	120.40
60	1200	108,828	90.69

For example, in Table 1, when 300 students view a taped TV program, the per student cost is $358.08. However, when the number of students is increased to 600, the cost per student drops to $179.82. As shown in subsequent tables, the situation is similar for live TV programs, audio reviews, and ancillary activities. The costs associated with the information systems (Table 5) do not show a similar trend since these costs are site specific.

Therefore, as the number of sites increases, the cost for information systems does not decline as markedly as the videotape production costs.

TABLE 2

COST OF 4 LIVE TELEVISED PROGRAMS

# of Sites with 20 Students/Site	# of Students	# of Panelist	Cost	
			per Course	per Student
15	300	2	$21,452	$71.51
15	300	4	24,652	82.17
30	600	2	21,584	35.97
30	600	4	24,784	41.31
45	900	2	21,716	24.13
45	900	4	24,916	27.68
60	1200	2	21,848	18.21
60	1200	4	25,048	20.87

Each table presents the costs for 15, 30, 45, and 60 sites with 20 students per site. The corresponding audience sizes are 300, 600, 900, and 1200. The figures for 300 students (15 sites) represent the original scale of AESP operation. The other figures represent doubling, tripling, and quadrupling the original effort. Twelve hundred students (60 sites x 20 students) was chosen to reflect the situation where one classroom site was located in each RESA or Local Development District in Appalachia.

TABLE 3

COST OF 12 FOUR-CHANNEL AUDIO REVIEWS

# of Sites with 20 Students/Site	# of Students	Cost	
		per Course	per Student
15	300	$13,716	$45.72
30	600	13,824	23.04
45	900	13,932	15.48
60	1200	14,040	11.70

TABLE 4

COST OF 12 ANCILLARY ACTIVITIES

# of Sites with 20 Students/Site	# of Students	Cost	
		per Course	per Student
15	300	$9,036	$30,12
30	600	12,384	20.64
45	900	15,732	17.48
60	1200	17,640	14.70

TABLE 5

COST OF ON-SITE LIBRARY AND INFORMATION RETRIEVAL SYSTEM

# of Sites with 20 Students/Site	# of Students	Retrieval System Uses per Student	Cost	
			per Course	per Student
15	300	3	$ 67,561	$225.20
15	300	10	88,981	296.60
30	600	3	126,859	211.43
30	600	10	169,699	282.83
45	900	3	186,157	206.84
45	900	10	250,417	278.24
60	1200	3	210,571	175.48
60	1200	10	214,855	179.05

It is possible that at some point increases in audience size would begin to have a negligible effect on per-student production cost. The reason for this is that the variable costs such as printing student response forms and analyzing the data gradually assumes such a large proportion of the total production cost that per-student cost is almost totally accounted for by individual analysis and printing charges. The basic development, production, and evaluation costs would become minimal.

Another variable of interest is the number of units produced. If the per-student cost for different numbers of units of a particular activity is compared for the same audience size, it is obvious that twice as many units cost twice as much using this cost model. This is true since a method of

diminishing costs for increased volume is not included in the model. The production costs are estimated as a linear function of the number of units.

The validity of this statement is evident in looking at Figures 1, 2, 3, and 4. Since 4 live programs cost $71.51 per student to produce (Table 2), 8 programs would cost twice as much, or $143.02 per student. Again, the situation is similar for taped programs, audio reviews, and ancillary materials.

In addition to assigning different values to the audience size and number of units produced in the cost formulas, the actual base costs (in the rectangles) can be assigned different values to reflect the degree of sophistication necessary in the programming for the prospective audience or the increased cost of producing the activity due to inflation. However, while an increase in the value of cost parameters causes per-student costs to rise, the cost does not rise as dramatically on a per-student basis if the course is intended for a large audience. For instance, if the development cost per taped program was increased to $5,000, the production cost increased to $15,000 and the evaluation cost increased to $4,000, it would cost $981.56 per student to produce 12 televised programs for 300 students, but only $246.56 per student to produce for 1200 students.

Manipulating the cost values in the on-site information support system demonstrates how cost constants may be adapted to describe different course emphases. If a second course is offered that is quite similar to one already given at a site, then much of the research on appropriate materials would already have been made and many of the materials would already be on site. In this case, the additional research and development

needs might cost no more than $1,000 and no more than $500 worth of materials would need to be added to each site library. This adjustment would reduce the cost of the information parameter for 300 students (15 sites) from $225.20 per student to $102.81. This is a realistic way to cut per-student cost by more than one half.

Description of Delivery Cost Formula

Once a learning activity is produced, regardless of whether a video-tape or a printed media is used, it must be delivered from the production center to the geographically dispersed sites where those taking the course meet. To arrive at a more accurate idea of what a learning activity actually costs, it is necessary to add delivery costs to the development and production costs.

For example, in estimating the cost of the ancillary activities, the cost for printing and mailing each unit was simply added on to the production cost formula (Figure 4). However, two different satellite systems were used in the AESP project, ATS-6 and the less powerful ATS-3. Thus, to account for their use in the delivery of programs from the Lexington studio to the sites, it is necessary to separate the costs for these two systems in the formula for the delivery costs. With delivery costs separated from production costs, it is sometimes possible to use the same delivery formula for two activities. For instance, in the AESP course, both the taped and the live television programs made use of ATS-6 as the delivery system for audio-video transmission. In Figure 6, this delivery system is depicted. However, in the case of the live interactive seminars,

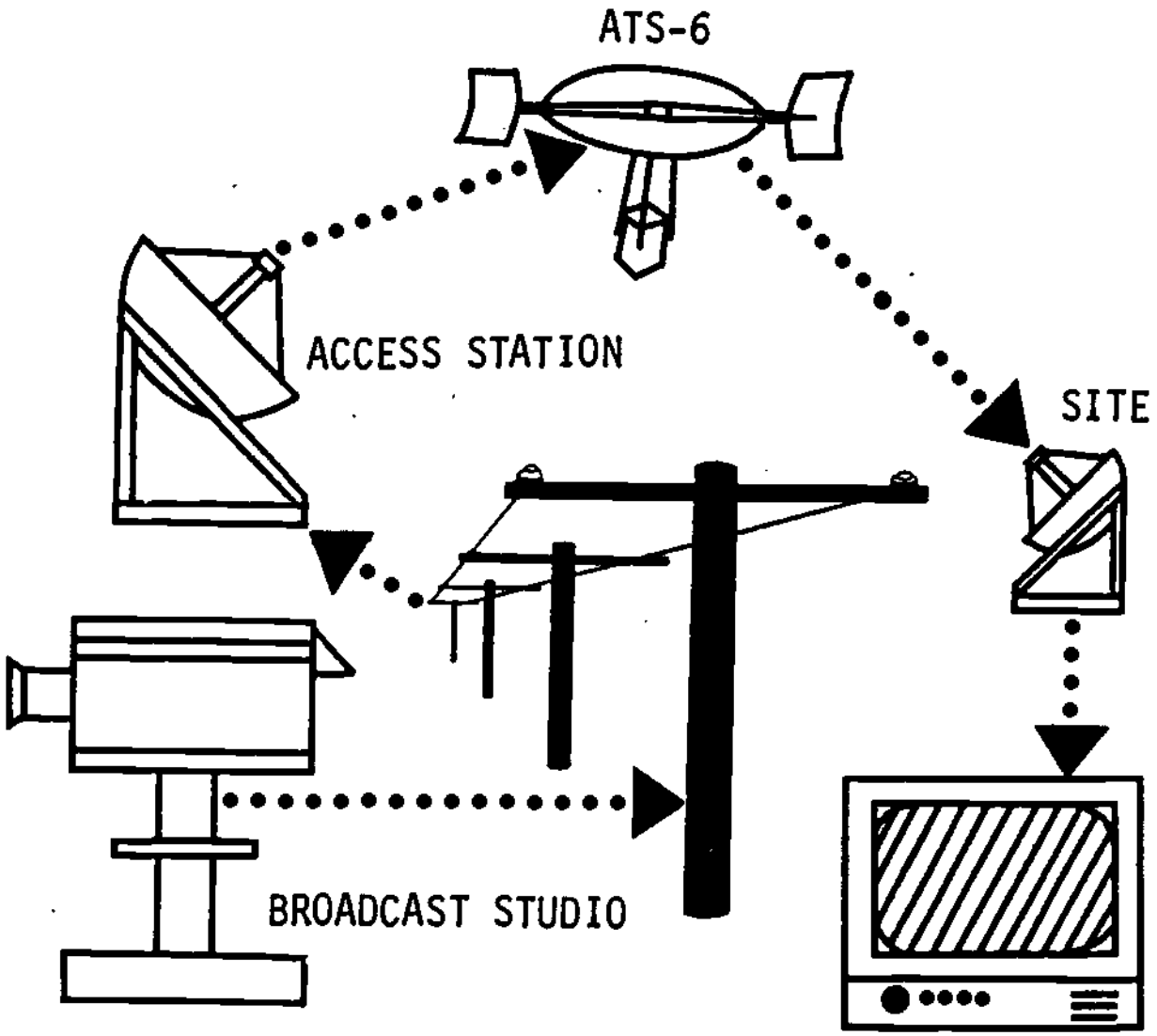


FIGURE 6: AUDIO-VIDEO DELIVERY SYSTEM

a second delivery system, using ATS-3, was also needed to transmit questions from the sites to the studio (see Figure 7).

The point is that dividing the delivery cost formula into discrete units makes various combinations possible. For instance, the cost for the delivery of audio reviews can be found by adding the cost for the delivery of televised programs to the cost formula for four-channel equipment at the site. This is true since the signals for the audio review use the same higher powered satellite delivery system as televised programs. Although the cost of the television set is included in this estimate, this does not necessarily inflate the results; the idea to use visual presentations to enrich the audio review is a possibility not realized in the summer courses simply because there was not sufficient time to develop accompanying visuals for the reviews. It is simple to set the value of the television set and maintenance at zero if television is not a factor in the audio review.

In the delivery parameter one of the units of measurement in the cost model is the per hour cost of the equipment. This figure is derived by dividing the cost of the equipment by its life expectancy in hours. The cost of an activity is then determined by the number of hours of 'life' the activity uses up. Additional costs included in the delivery parameter are the rental cost of the satellites per hour and the monthly maintenance cost for the equipment. Appendices G, H, and I include a breakdown of the equipment, rental, and maintenance costs, as well as documentation of the cost figures.

The three cost formulas in the delivery parameter deal with the cost of transmitting via satellite to site receivers live and taped tele-

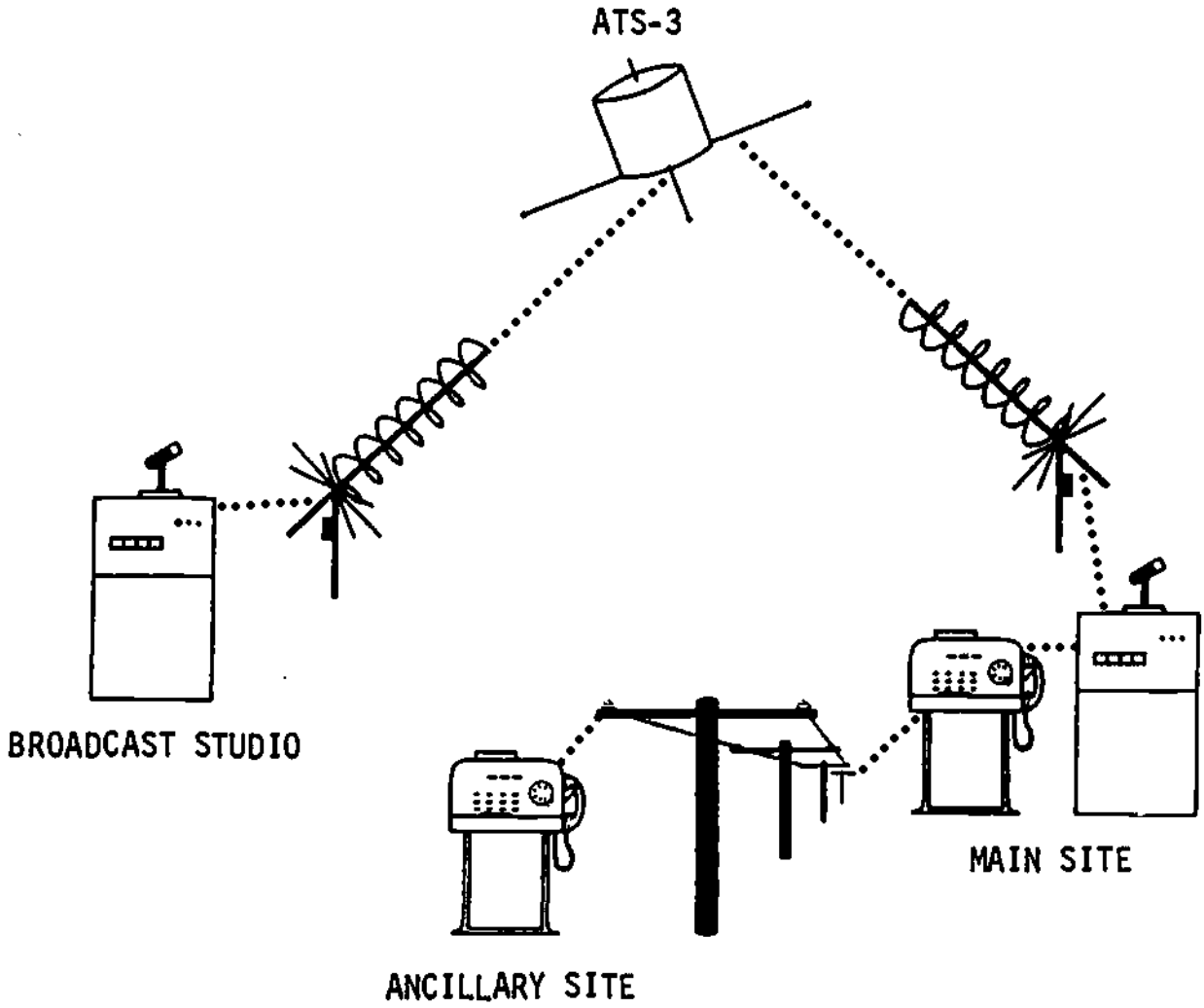


FIGURE 7: VHF-TELETYPE RELAY SYSTEM

vision programs (Figure 8), voice/data (Figure 9) and four-channel audio equipment (Figure 10). With these formulas used singularly or in combination, the cost for the delivery of different numbers of units of various lengths for a variety of audience sizes can be obtained.

Some of the cost principles described in the production parameter function similarly in the delivery mode. For example, the more students taking the course, the less the per-student cost for delivery. The delivery cost for 12, 30-minute taped televised programs is $35.96 per student for 300 students, compared to $13.46 per student for 1200 students (Table 6). Similarly, the delivery cost for 12, 45-minute live or taped television programs is $19.04 for 300 students compared to $9.04 for 1200 students (Table 6).

To find the per-student delivery cost for the interactive seminars, it is necessary to add to the cost for the transmission of live programs the cost for the transmission of students' questions from the sites to the studio. As depicted in Figure 7 (audio equipment configuration), the seminar questions were relayed from the ten ancillary sites by landline teletype to the five main sites for VHF transmission to the broadcast studio. The cost formula for the delivery of voice/data via satellite is depicted in Figure 9.

The cost for the delivery of voice/data by satellite and landline for different audience sizes is presented in Table 7. In the initial AESP project, five of the fifteen sites (or 1 out of 3) had the capability to transmit questions by satellite, and all of the sites had landline capability.

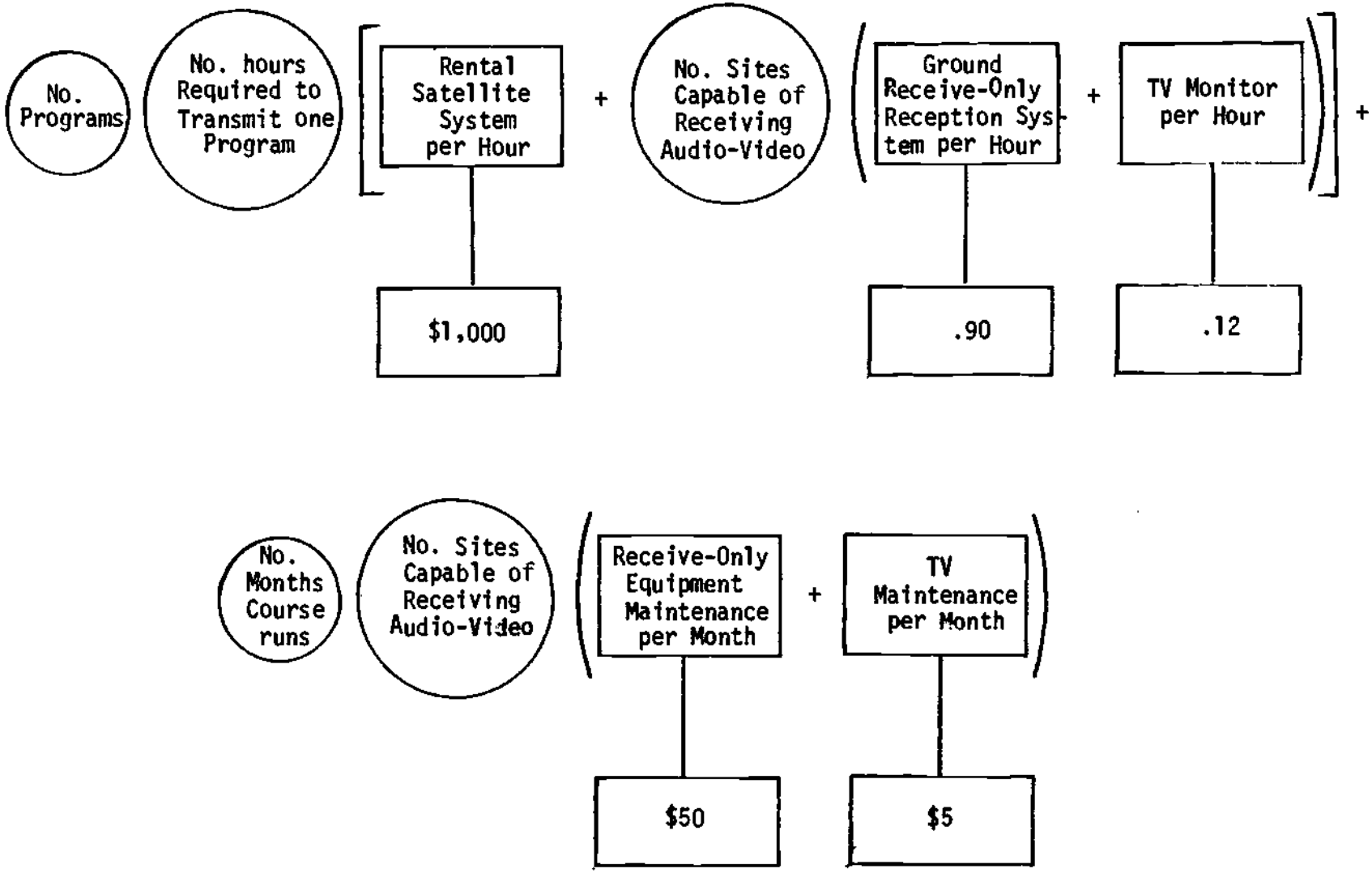


FIGURE 8: SATELLITE DELIVERY OF TELEVISED PROGRAM COST FORMULA

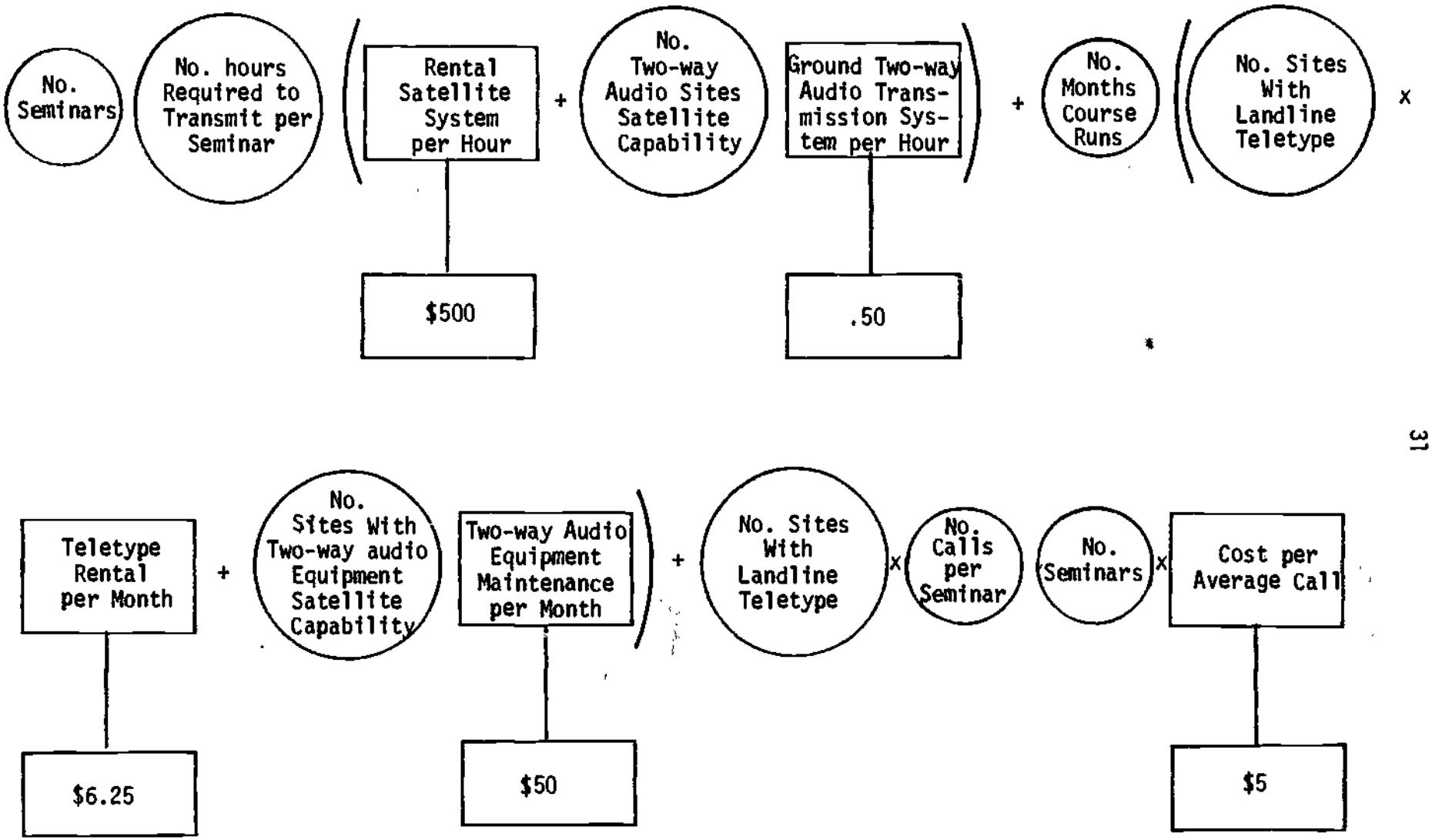


FIGURE 9: SATELLITE DELIVERY OF VOICE/DATA COST FORMULA

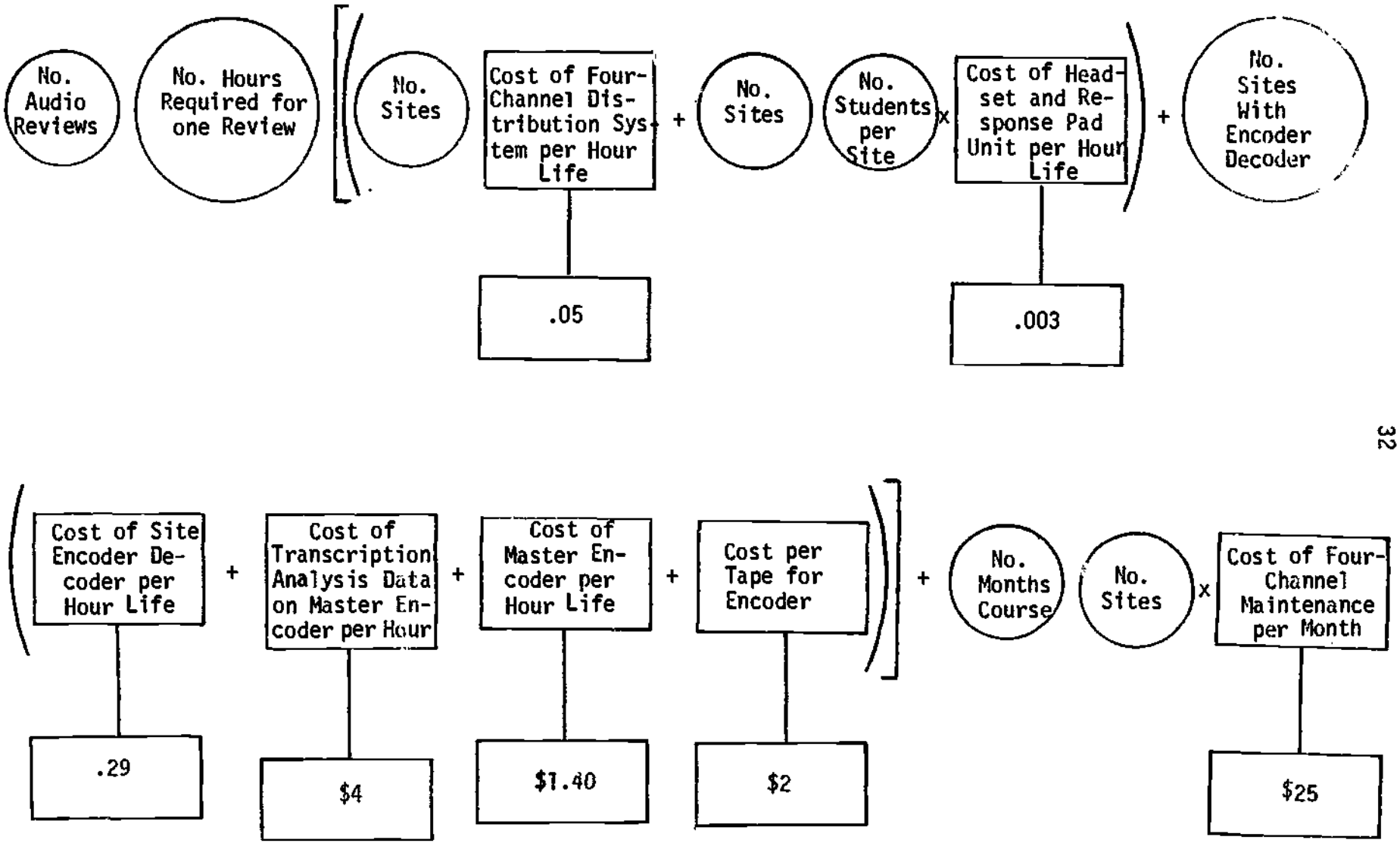


FIGURE 10: FOUR-CHANNEL AUDIO REVIEW EQUIPMENT (IN ADDITION TO RECEIVE-ONLY SATELLITE-ANTENNA SYSTEM)

TABLE 6

COST OF DELIVERY OF LIVE OR TAPED TELEVISED PROGRAMS AND FOUR-CHANNEL AUDIO BY SATELLITE

of Sites with Students/Site	# of Students	# of Hours per Transmission	# of Programs	Cost	
				per Course	per Stude
15	300	.33	12	$ 5,671	$18.90
30	600	.33	12	7,381	12.30
45	900	.33	12	9,092	10.10
60	1200	.33	12	10,802	9.00
15	300	.75	12	10,788	35.96
30	600	.75	12	12,575	20.96
45	900	.75	12	14,363	15.96
60	1200	.75	12	16,151	13.46
15	300	1.00	4	5,711	19.04
30	600	1.00	4	7,422	12.37
45	900	1.00	4	9,134	10.15
60	1200	1.00	4	10,844	9.04

A course length of two months is assumed. The length of transmission include program length plus satellite warm up time, therefore, .33 hours corresponds to the 15 minute audio review, .75 refers to a half hour taped program, and 1.00 refers to a 45 minute live seminar.

TABLE 7

COST OF DELIVERY OF VOICE/DATA BY SATELLITE AND LANDLINE
FOR 4 LIVE 1 HOUR TV PROGRAMS FOR 2 MONTHS

# of Sites with Satellite Capability	# of Sites with Landline Capability	# of Students	Cost	
			per Course	per Student
5	15	300	$5,008	$16.70
10	30	600	6,015	10.03
15	45	900	7,023	7.80
20	60	1200	8,030	6.69

The figures presented in Table 7 assume that a similar ratio of satellite capability to landline capability would continue to exist. Once again, an increased audience size reduces the per-student cost of the delivery of voice/data by satellite. As can be seen in Table 7, delivery to 300 students (15 sites) cost $16.70, while the cost of delivery to 1200 students (60 sites) drops to $6.69.

While, according to the production formulas, doubling the number of activities produced doubles the cost of production, it costs less than twice as much to deliver double the number of programs. The cost formula presented in Figure 8 indicates that maintenance costs are constant, and therefore are not affected by the number of programs. Thus, under this model the more programs broadcast during a month, the less maintenance cost assignable per program.

By inspecting the cost formula for television delivery by satellite even more closely, it becomes easier to see why costs per student decrease as audience size increases. The cost of having to equip a site is more than offset by distributing across a greater number of students the fixed costs for transmitting a particular number of hours by satellite.

It should be pointed out that the number of students effectively accommodated at one time by one television set and satellite receiver is limited to between 20 to 50 unless additional TV monitors, receivers, and amplifiers are purchased. Until formulas are developed to describe this expansion, it is necessary to treat larger numbers of students at a site that can be accommodated in one room at one time as an additional site. Under this model twenty rooms in a school simultaneously receiving television by satellite have to be treated as 20 sites.

To find out what it would cost to deliver a particular number of audio reviews to a particular number of sites, it is necessary to use both the cost formula for the delivery of televised programs, since the four audio channels are transmitted above the video spectrum, and the cost formula for the site audio review equipment, since special equipment is necessary to make the selection of specific audio channels possible. Further, if visuals are used with the four-channel audio, it is necessary to include the cost of the TV receiver and maintenance. The cost for the satellite delivery of the four-channel audio reviews is included in Table 6. As shown in the tables, the total hours of transmission are .33. This transmission time allows for a 15-minute review and an approximate 5-minute warm up time necessary for the satellite. The cost for the audio review equipment is

outlined in Table 8 for different audience sizes. Because the equipment is relatively site specific, increasing the number of sites does not lower per-student cost. The cost per student for review equipment is $3.23 for 300, 600, 900 or 1200 students. One way to reduce this cost would be to have more than 20 students at each site.

TABLE 8

COST OF 12 4-CHANNEL AUDIO REVIEW EQUIPMENT*

# of Sites with 20 Students/Site	# of Students	# Sites with Encoder	Cost	
			per Course	per Student
15	300	7	$ 970	$3.23
30	600	14	1,939	3.23
45	900	21	2,909	3.23
60	1200	28	3,879	3.23

*Each review is assumed to last .25 hours with .08 hours warm up time, therefore the length of each transmission is .33 hours. The course is assumed to last two months.

Description of Local Coordination Cost Formulas

The local coordination cost formula includes the cost of the site coordinator - needed at each site - the cost for an administrator, and a faculty consultant - needed for each site triangle (each group of 3 sites). If a site coordinator is paid hourly, then the more time spent in class, the greater the salary. However, the amount of time spent in class depends on the length and number of the various classroom learning activities

prescribed for the course. Besides estimating the cost for site coordinators monitoring a particular course, the local coordination cost formula in Figure 11 can estimate what it would cost for administrators and faculty consultants for every three triangles, centralized training of site coordinators, and overhead to the RESA's for the use of their facilities. Appendix J provides a breakdown of each of these cost factors.

The cost values presented in Figure 11 are based on what these activities cost during an experiment. If courses were regularly run, the per-course cost for local coordination might not be so high, since it might be expected that the indirect overhead to the RESA's might decrease and that site coordinators monitoring a course might not need retraining. Of course, as is the case with all the costs, alternative ways for performing an activity such as teaching the coordinators by means of a slide show, can become part of the cost model.

The per-student cost for local coordination for different audience sizes is presented in Table 9. The cost for 300 students (15 sites) is $445.14 and the cost for 1200 students (60 sites) is $438.70. Increasing the audience size does not have much of a decreasing effect on the local coordination parameter. The cost decreases slightly because some of the workshop costs are independent of the number of sites. One way to lessen costs would be to reduce the number of people used if it becomes evident that a faculty consultant, administrator, and three site coordinators are not needed for every three sites.

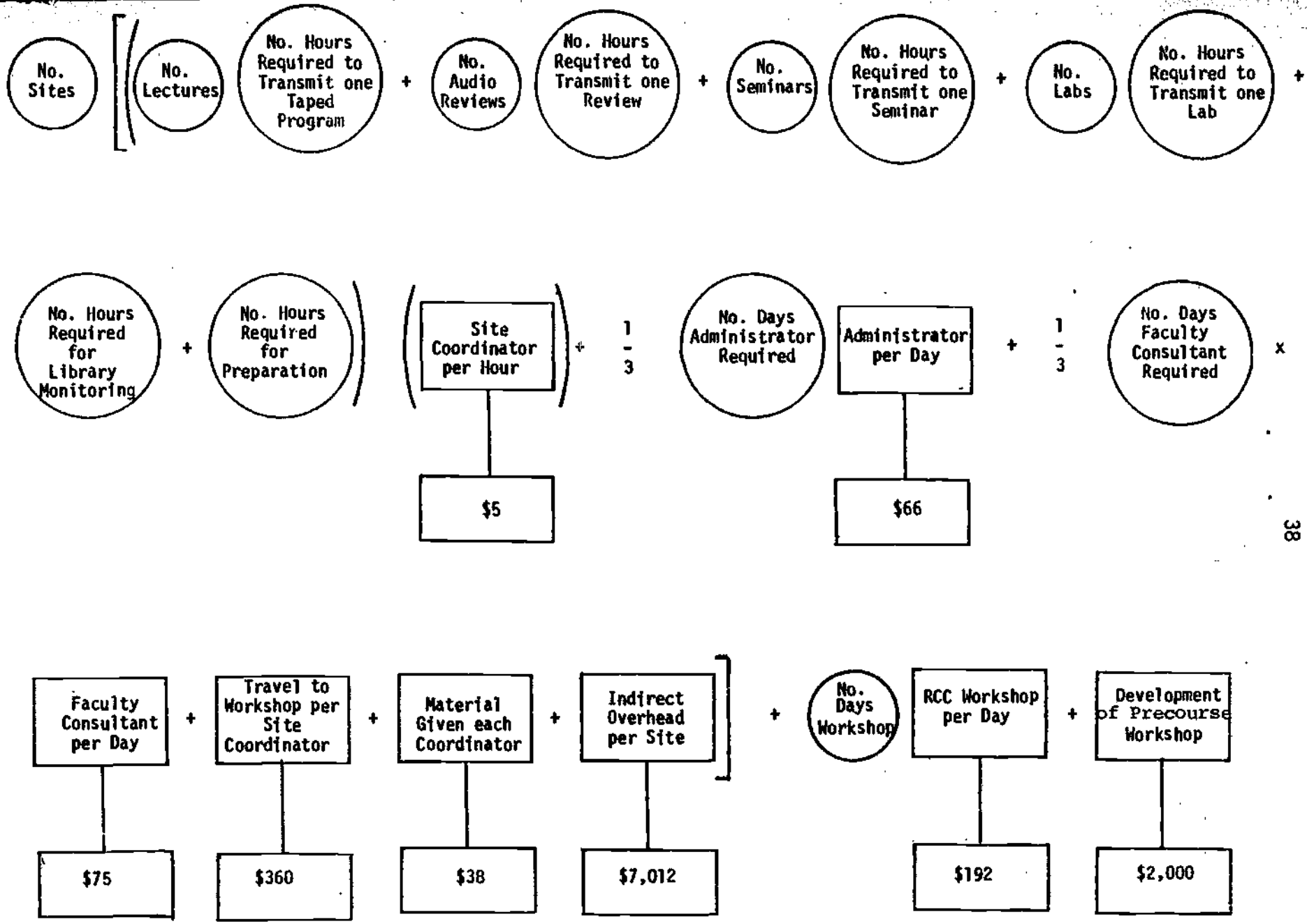


FIGURE 11: LOCAL COORDINATION COST FORMULA

TABLE 9

LOCAL COORDINATION COST*

# of Sites with 20 Students/Site	# of Students	Cost	
		per Course	per Student
15	300	$133,541	$445.14
30	600	264,506	440.84
45	900	395,471	439.41
60	1200	526,436	438.70

*Site coordinator is assumed to work 70 hours/course; administrators 33 days, faculty consultant ten days, and the workshop is assumed to last three days.

Description of Central Coordination

Central coordination costs are a function of management costs for both the ARC and the RCC as well as indirect costs and evaluation costs. The values presented in Figure 12 are based on the overall management costs for the AESP project. Because four courses were offered, the cost per course was calculated by dividing the total cost by four for each element in the formula. A detailed account of each number presented in Figure 12 is included in Appendix K.

The cost of central coordination per student for different audience sizes is presented in Table 10. The cost of $790.11 per student for an audience size of 300 (15 sites) is unrealistically high due to the small number of courses offered. This factor also has an elevating effect on the costs for the 600 students ($395.36), 900 students ($263.77) and 1200 students

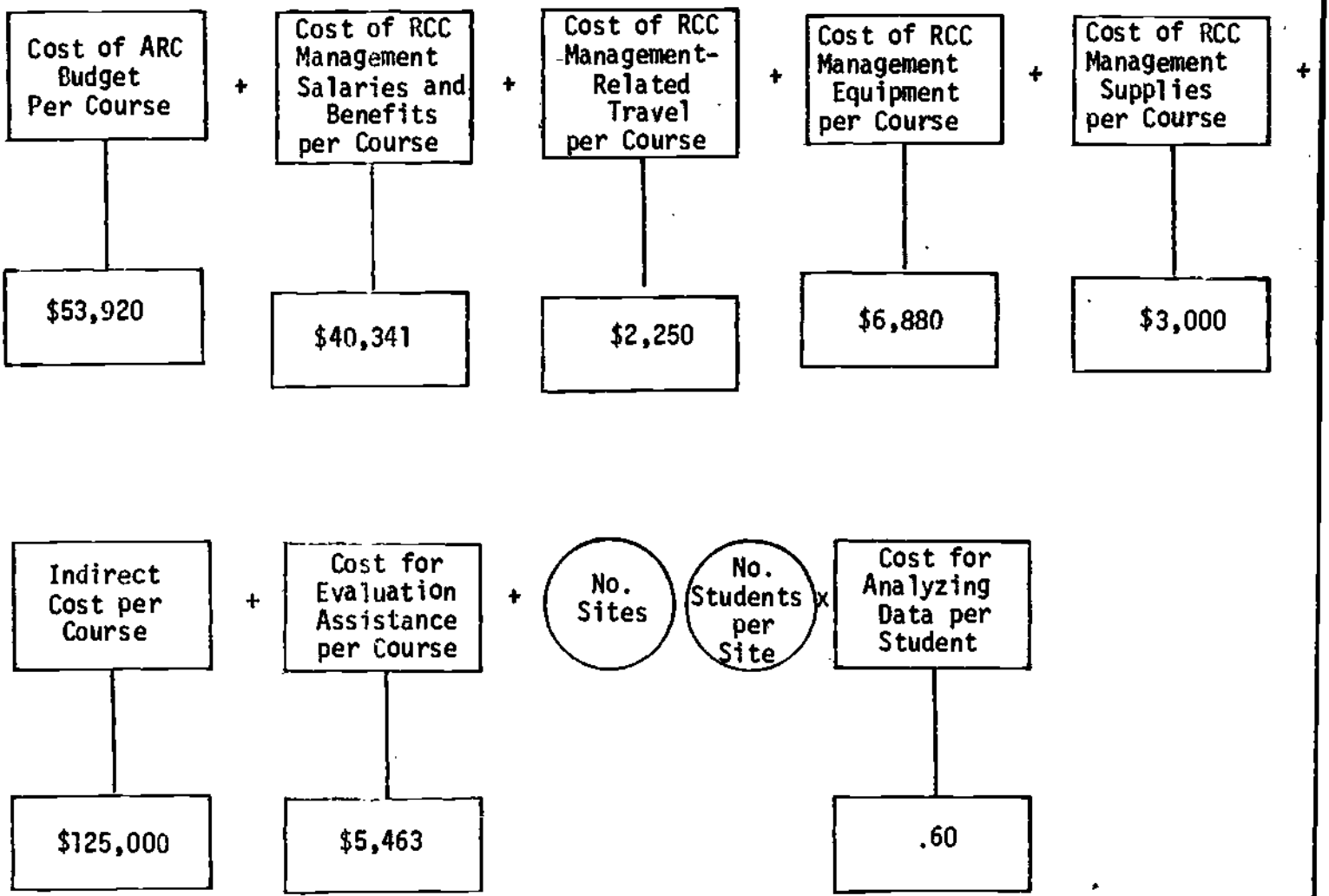


FIGURE 12: CENTRAL COORDINATION COST FORMULA

TABLE 10

CENTRAL COORDINATION COST

# of Sites with 20 Students/Site	# of Sites	Cost	
		per Course	per Student
15	300	$237,034	$790.11
30	600	237,214	395.36
45	900	237,394	263.77
60	1200	237,574	197.98

($197.98). More realistically, if a larger number of courses were offered, the central coordination cost would decrease considerably.

Another reason for the cost for central coordination in the AESP project is the experimental nature of the effort. As was noted in the local coordination parameter, additional costs were incurred in this experiment that would not be present when courses are regularly run. Therefore, central coordination costs could be expected to drop when the project was fully functioning as well as when a larger number of courses were offered.

Description of a Course

The total cost for a course is made up of the cost for development, production, and evaluation, delivery; local coordination; and central coordination. In Table 11, total course costs are given for a course consisting of 12 taped televised programs, 4 live seminars and 12 audio reviews

TABLE 11

PER-STUDENT COST OF AN AESP COURSE FOR DIFFERENT NUMBERS OF STUDENTS

Cost Elements	Number of Students		
	300 (15 Sites)	600 (30 Sites)	1200 (60 Sites)
Development, Production, and Evaluation			
12 taped TV programs	$358.08	$179.82	$90.69
4 live TV programs (with 4 panelists)	82.17	41.31	20.87
12 audio reviews	45.72	23.04	11.70
12 ancillary activities	30.12	20.64	14.70
site library	225.20	211.43	175.48
Subtotal	$741.29	$476.24	$313.44
Delivery (satellite)			
12 taped TV programs	$35.96	$20.96	$13.46
4 live seminars	35.74	22.40	15.73
12 audio reviews	22.13	15.53	12.23
Subtotal	$93.83	$58.89	$41.42
Local coordination	$445.14	$440.84	$438.70
Central coordination	$790.11	$395.36	$197.98
TOTAL	$2,070.37	$1,371.33	$991.54

delivered by satellite, and 12 laboratory sessions with support library facilities. The course has the full local and central management structure described in the cost formula. The total costs per course per student, as given in Table 11, are $2,070.37, $1,371.33, and $991.54 for an audience size of 300, 600, and 1200 students respectively.

Two realistic ways to reduce costs are to use the same course materials on different occasions and to offer more than one course at a time. The cost of producing a set of learning activities for a course can be thought of as a one-shot proposition. Therefore, the more times a course is used, the less production cost to be attributed to each student. For example, if the assumption is made, that the same course materials could be used five times, this would reduce per student cost to approximately $148, $95, and $62 for audience sizes of 300, 600, and 1200, respectively. This adjustment does not take into account the cost associated with the loss, destruction, or revision of some materials. The adjusted costs were obtained by multiplying the original production cost by a factor of one fifth.

Similarly, central management costs would be cut if audience size were increased and several courses were offered simultaneously. It seems reasonable to assume that the present central coordination system could coordinate a larger audience size and an increase in courses without a proportional expansion. If three courses were offered simultaneously, central coordination costs would drop to $263, $79, and $39 for 300, 600, and 1200 students, respectively. These figures were obtained by multiplying the original cost by one third.

In addition, local coordination costs might be decreased by increasing the number of courses simultaneously managed by local administrators or by eliminating some of the components, such as the faculty consultant. Local universities who receive tuition for AESP courses might be expected to provide some faculty consultant services. Or, the local administrator could contact the local universities and obtain credit

for the students.

The question asked at the beginning of this report was "Is this a good way to spend our money?" The comparison of satellite delivered cost and the cost of traditional graduate education provides one possible answer to the question. A number of studies have indicated that the cost for satellite delivery of televised programs has been lower than various alternative systems such as terrestrial microwave delivery of signals (Hesselbacher, undated; Hupe, 1974; and Lusignan, Potter, and Janky, 1975).

While costs for traditional graduate education vary from institution to institution, a recent cost study at the University of Kentucky indicated that the per-student cost for the three-hour graduate level course in education was $1,694, based on a per hour cost of $564.67 per student at the master's level (University of Kentucky, 1975). Thus the cost per student of offering graduate level education by satellite even on the modest scale of the original AESP project is economically feasible. Further, by merely doubling the number of students who participate in a satellite delivered course, the cost per student drops to $1,371, below the traditional education cost of $1,694. The economic feasibility of graduate education delivered by satellite to isolated areas is more than evident when the number of participating students is increased to 1200, a rather moderate audience size. In addition, this feasibility is even more evident when the possibility of using the same materials more than once and offering several courses simultaneously is considered.

CONCLUSIONS

This model is restricted to the learning activity format actually used in AESP courses in 1974. The value of the model could be increased by the costing of alternative activity formats and delivery systems. However, regardless of how sophisticated a model is, a cost model simply makes explicit the costs associated with choosing different ways to accomplish general project goals. It is still necessary for those making decisions to look at the outputs of the different systems, weigh the costs against other less tangible benefits, and decide which system is preferable.

Validity of the Information

The validity of the information produced by this cost model depends on the accuracy of the interrelationships specified in the model and the accuracy of the costs figures assigned to the qualitative elements in the model. This preliminary version of the model provides the most accurate information possible given the data available at this time, and even ball-park cost figures can be used to demonstrate the relationship between variables. When more accurate cost information is available, the cost variables can be altered to obtain more precise cost estimates. The greatest value of this initial version of in-service education by satellite cost model may be that it may act as a catylist to precipitate continuous revisions of the model and re-evaluations of the project from a cost point of view.

APPENDICES

APPENDIX A

TAPED PROGRAM PRODUCTION AND DEVELOPMENT COST FORMULAS

Development of 12 scripts

1.	Total salaries and benefits for Director of Reading Component, Materials Specialist, and Graduate Assistant	$14,434
2.	Current expenses	
	a) Office supplies	100
	b) Travel	3,000
	c) Duplicating and printing	500
	d) Searches	120
	e) Consultants	1,700
	Total Current Expenses	5,420
	Total direct cost	19,854
	Total indirect cost (55% salaries and benefits)	6,903
	Cost per program (total ÷ 12)	1,655
	Cost per student (cost per program ÷ 300)	5.52

Production of 12 taped programs

1.	Total salaries and benefits for Producer-director, Cinematographer, Artist, Audio Technician, TV Engineer, and Production Crew	28,997
2.	Current expenses	
	a) Production supplies	27,080
	b) Telephone	400
	c) Studio use	6,480
	d) Travel	5,320
	e) VMatic and monitor	1,668
	f) Consultants	3,500
	Total Current Expenses	44,448
	Total direct cost	73,445
	Total indirect cost	14,240
	Cost per program	6,120
	Cost per student	$ 20.40

APPENDIX B

EVALUATION COSTS

Evaluation component budget for 1 course

1. Total salaries and benefits

Formative evaluation: Evaluation Director and Evaluator	$ 6,068
Summative evaluation: Evaluation Director and two Evaluators	13,864
Total Salaries and Benefits	19,932

2. Current expenses

a) Office supplies	1,500
b) Travel	1,500
c) Communications	1,000
d) Consultants	2,623
e) Computer	460
f) Technical reports	300
g) Evaluation instruments (printing and analysis)	900
Total Current Expenses	8,283
Total direct cost	28,215
Total indirect cost	9,788

Breakdown of AESP evaluation budget for 1 course by activity

(activity costs are based on the total direct evaluation cost (28,215) minus the cost of printing and analyzing the evaluation instruments (900) = $27,315)

	Per Course
1. 12 lectures @ 50% of 27,315	1,138
2. 4 seminars @ 15% of 27,315	1,024
3. 12 audio reviews @ 10% of 27,315	228
4. 12 ancillary activities @ 3% of 27,315	68
5. Information systems @ 2% of 27,315	546
6. Management @ 20% of 27,315	$ 5,463

APPENDIX B--CONTINUED

Breakdown of cost for analyzing data per student by activity

(activity costs are based on the cost of printing and analyzing the evaluation instruments ($900).

	Per Student
1. 12 lectures @ 50% of 900 (÷12)(÷300)	.13
2. 4 seminars @ 15% of 900 (÷4)(÷300)	.11
3. 12 audio reviews @ 10% of 900 (÷12)(÷300)	.03
4. 12 lab activities @ 3% of 900 (÷12)(÷300)	.01
5. Information systems @ 2% of 900 (÷300)	.06
6. Management @ 20% of 900 (÷300)	.60

APPENDIX C

LIVE TELEVISION COST FOR DEVELOPMENT, PRODUCTION, AND SEMINAR PANELIST

Development of live seminar	
Total salaries and benefits for Mission Director	$ 1,230
Total direct cost	1,230
Cost per program (1230 ÷ 4)	308
Production	
1. Total salaries and benefits for Producer Director, Artist, TV Engineer, and Production Crew	4,290
2. Current expenses	
Production supplies	8,500
Total direct cost	12,790
Total indirect cost	2,107
Cost per program (÷4)	3,198
Cost of seminar panelist	
1. Honorarium 8 @ $100/day	800
2. Per diem 8 @ $25/day for 2 days	400
3. Travel 8 @ $250/person	2,000
Total cost	3,200
Cost of 1 seminar panelist (3,200 ÷ 8)	$ 400

APPENDIX D

FOUR-CHANNEL AUDIO REVIEW PRODUCTION COST FORMULA

Development		
1. Total salaries and benefits for Director and Reading Specialist		$ 4,490
2. Current expenses		
a) Narrator		200
b) Duplicating		23
	Total Current Expenses	223
Total direct cost		4,713
Total indirect cost		2,147
Cost per program		393
Production		
1. Total salaries and benefits for Audio Technician and TV Engineer		2,755
2. Current expenses		
Production supplies		3,404
Total direct cost		6,159
Total indirect cost		1,353
Cost per program		$ 513

APPENDIX E

COST FOR DEVELOPMENT, PRINTING AND MAILING OF ANCILLARY ACTIVITIES

Development		
1. Total salaries and benefits for Mission Director and Graduate Assistant		$ 4,654
2. Current expenses		
a) Searches		120
b) Supplies		100
	Total Current Expenses	220
Total direct cost		4,874
Total indirect cost		2,295
Cost per program		406
Printing and mailing per unit per student		
Printing and mailing		
3,000 for 300 students for 12 activities		$ .83

APPENDIX F

ON-SITE INFORMATION SUPPORT SYSTEM

Development	
1. Total salaries and benefits for Mission Director and Systems Development Specialist	$ 6,492
2. Current expenses	
a) Supplies	400
b) Printing and duplicating	425
c) Computer	400
Total Current Expenses	1,225
Total direct cost	7,717
Total indirect cost	3,105
On-site library per course	2,500
Cost for support materials per student	
$840 per site for 20 students' books and tests	42
Cost for retrieval system per use	$ 10

APPENDIX G

SATELLITE DELIVERY OF TELEVISED PROGRAMS AND FOUR-CHANNEL AUDIO

Rental satellite per hour	1,000
The rental cost for a 50 transponder satellite delivery system for audio-visual transmission is $1,000/hour. This is a middle figure in the range given in The Development of the Public Service Satellite Consortium by Lusignan, Potter, and Jankey.	
Ground receive-only reception per hour	.90
The ground receive-only equipment for reception of satellite delivered audio-video signals is $4,500 for the parabolic antenna system and receiver used in AESP. The figure of .90 per hour was derived by dividing the cost by the expected life, 5,000 hours - a conservative estimate based on 1000 hours per year of use for 5 years.	
TV Monitor per hour	.12
Color TV receivers cost $600 per site;this figure was supplied by a commercial supplier of television sets for schools. The .12 per hour figure is based on a conservative estimate for the life of the equipment of 5,000 hours based on 5 years with 1,000 hours of use per year.	
Receive-only equipment maintenance per month	50
Maintenance on one-way video equipment was $600 per site per year, or $50 per month. This figure was supplied by FRMS who were in charge of the ground reception equipment for the AESP.	
TV maintenance per month	5
TV maintenance was $60 per year, or $5 per month per site. This figure was supplied by a company offering maintenance contracts.	

APPENDIX H

FOUR-CHANNEL AUDIO REVIEW EQUIPMENT

Four-Channel distribution system per hour life Initial cost was $400, and assuming a 5 year life, 50 weeks a year, 5 days a week, and 7 hours per day, per unit life is	$ .05
Headset and response pad unit per hour life Initial cost was $30, and assuming a 5 year life, 50 weeks per year, 5 days per week, and 7 hours per day, per unit life is	.003
Site encoder-decoder per hour life Initial cost was $2500, and assuming a 5 year life, 50 weeks per year, 5 days per week, and 7 hours per day, per unit life is	.29
Transcription data on master encoder People were paid $4/hour to transcribe	4.00
Master encoder per hour life Initial cost was $12,500 and assuming a 5 year life, 50 weeks per year, 5 days per week, and 7 hours per day, per unit life is	1.40
Tape per encoder	2.00
Four-channel maintenance per month	$ 25.00

APPENDIX I

SATELLITE DELIVERY OF VOICE/DATA COST

Rental satellite system per hour	$ 500.00
Rental cost for a 20 transponder satellite delivery system for two-way radio transmission was $500/hr. This is a low figure in the range given in the Development of the Public Service Satellite Consortium by Lusignan, Potter, and Janky.	
Ground two-way audio transmission per hour	.50
The cost for two-way audio equipment for reception or transmission of audio or data was $2,500 for the helical antenna system and the VHF console. The figure of $.50 per hour was derived by dividing the cost by the expected life of 5,000 hours. This is a conservative estimate based on 1,000 hours per year of use for 5 years.	
Teletype rental per month	6.25
Teletype rental cost was $75/yr or $6.25 per month per site. This is the base rental charge made by the leasing company.	
Two-way audio equipment maintenance per month	50.00
Maintenance of two-way audio equipment was $600 per site per year, or $50 per site per month. This figure was supplied by the FRMS who were in charge of the ground reception equipment for the AESP.	
Cost of average call	$ 5.00

APPENDIX J

LOCAL COORDINATION COST

Cost of site coordinator by activity

1.	Taped Programs 12 taped programs of .75/hr. @ $5/hr.	$ 45
2.	Audio reviews 12 audio reviews of .33/hr. @ $5/hr.	40
3.	Live TV programs 4 live TV programs of 1 hr. @ $5/hr.	20
4.	Laboratory activities 12 lab activities of 2.67 hr. @ $5/hr.	160
5.	Library monitoring 16 hours @ $5/hr.	80
	Total for Site Coordinator	345

Cost of administrator and faculty consultant

Total salaries and benefits

Administrator per triangle	726
Faculty consultant per triangle 10 days @ $75/day for 3 sites	250
Subtotal	976

Workshop costs

1. Travel to workshop for site coordinator

a)	Travel	200
b)	Food	100
c)	Lodging	60
	Subtotal	$ 360

APPENDIX J--CONTINUED

2.	Cost of materials given each coordinator	
	a) 2 sets of ancillary materials @ $6.50/set	$ 13
	b) Other printed materials	10
	c) Procedure manuals	15
	Subtotal	38
3.	Cost incurred by RCC for each workshop day	192
4.	Development of workshop	2,000
	Other costs not directly related to course administration, but associated with the overall conduct of the project	$ 7,012

Each site was given $8,333 per course. Of this $1,321 be accounted for by site coordinator, administrator and faculty salaries, therefore $7,012 remains as overhead per site.

APPENOIX K

CENTRAL COORDINATION COST

ARC budget per course

1.	Total salaries and benefits for Associate Director, Coordinator, and Secretary	$32,920
2.	Current expenses	
	a) Supplies	5,000
	b) Travel	10,000
	c) Consultants	2,000
	d) Communication	2,000
	e) Printing	2,000
	Total Current Expenses	21,000
	Total direct cost	53,920
	Other administrative costs	16,225

RCC budget

1.	Total salaries and benefits for Director, Deputy Director, Administrative Assistant, Management Information Specialist, and Secretaries	40,341
2.	Current expenses	
	a) Supplies	3,000
	b) Equipment	6,880
	3 typewriters @ $540	
	2 Sony vumatic and monitor @ $2,630	
	c) Travel	2,250

Indirect cost per course $125,000

The total indirect cost for two years of the project was $500,000, therefore for one course it is $125,000. This cost helped to defray the costs associated with office space, use of the television studio and equipment, use of university personnel, university administrative costs, etc.

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